PB-238 481

FEASIBILITY OF OVERLAND-FLOW TREATMENT OF FEEDLOT RUNOFF

Richard E. Thomas

Robert S. Kerr Environmental Research Laboratory

Prepared for:

National Environmental Research Center

June 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-660/2-74-062	2. PB 238 481
4. TITLE AND SUBTITLE: FEASIBILITY OF OVERLAND-FLOW TREATMENT OF FEEDLOT RUNOFF	5. REPORT DATE: June 1974 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Richard E. Thomas	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Robert S. Kerr Environmental Research Laboratory, Post Office Box 1198, Ada, Oklahoma 74820	10. PROGRAM ELEMENT NO. 1BB045 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS: U.S. Environmental Protection Agency, National Environmental Research Center, Office of Research and Development, Corvallis, Oregon 97330	13. TYPE OF REPORT AND PERIOD COVERED: Final 10/71 to 6/73 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES	

16. ABSTRACT

This report covers six months of pilot-scale experiments and six months of data collection at one field experiment.

The pilot-scale studies were conducted on plots which were 6-feet by 30-feet with a 4.5 percent slope. These studies indicated that: (1) loadings of 2 to 3 inches per week were suitable for field testing, (2) the weekly load should be applied in fractional increments at daily to three times per week frequencies, and (3) instantaneous spray rates should be less than 0.10 inch per hour.

The field studies covered in this report were initiated at a 12,000-head capacity feedlot and utilized a four-component train for runoff collection and treatment. The treatment train included collection lagoons, a storage reservoir, the overland-flow area, and a final polishing pond. Data from the short period of operation (six months) corroborated the results of the pilot-scale study and indicated that inclusion of the final polishing pond substantially improved the overall performance.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Agricultural wastes Waste treatment Nitrogen cycle Phosphorus cycle	Overland flow	02/03 Pri. 14/03 Sec.

18. DISTRIBUTION STATEMENT: Release unlimited.	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 36
	20. SECURITY CLASS *(This page)*	22. PRICE MF. 2.25

EPA Form 2220-1 (9-73)

☆ U.S. GOV

Reproduced by NATIONAL TECHNICAL INFORMATION SERVICE US Department of Commerce Springfield, VA. 22151

I/63 REGION 10

EPA-660/2-74-062
December 1974

FEASIBILITY OF OVERLAND-FLOW TREATMENT OF FEEDLOT RUNOFF

by

Richard E. Thomas
Robert S. Kerr Environmental Research Laboratory
Ada, Oklahoma 74820

Project 16080 WNU
Program Element 1BB045
ROAP 21-ASH/Task 004

NATIONAL ENVIRONMENTAL RESEARCH CENTER
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CORVALLIS, OREGON 97330

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Stock No. 5501-00974

ia

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into five series. These five broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The five series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY STUDIES series. This series describes research performed to develop and demonstrate instrumentation, equipment and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

This report has been reviewed by the National Environmental Research Center--Corvallis, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

A three-phase study was initiated to explore the practicality of adapting the overland-flow approach to treatment of runoff from cattle feedlots. A six-month period of pilot-scale experiments to determine the feasibility of the concept was to be followed by field experiments to develop loading rate information and demonstration projects to verify the utility of the approach. This report covers the six-month period of pilot-scale experiments and six months of data collection at one field experiment.

The pilot-scale studies were conducted on plots which were 6-feet by 30-feet with a 4.5 percent slope. These studies indicated that: (1) loadings of 2 to 3 inches per week were suitable for field testing, (2) the weekly load should be applied in fractional increments at daily to three times per week frequencies, and (3) instantaneous spray rates should be less than 0.10 inch per hour.

The field studies covered in this report were initiated at a 12,000-head capacity feedlot and utilized a four-component train for runoff collection and treatment. The treatment train included collection lagoons, a storage reservoir, the overland-flow area, and a final polishing pond. Data from the short period of operation (six months) corroborated the results of the pilot-scale study and indicated that inclusion of the final polishing pond substantially improved the overall performance.

This report was submitted in fulfillment of Project Number 16080 WNU, by the Robert S. Kerr Environmental Research Laboratory under the sponsorship of the Environmental Protection Agency. Work was completed as of June 1973.

CONTENTS

Sections		Page
I	CONCLUSIONS	1
II	RECOMMENDATIONS	2
III	INTRODUCTION	3
IV	EXPERIMENTAL METHODS	5
V	OPERATIONAL AND EVALUATION PHASES	8
VI	DISCUSSION	21
VII	REFERENCES	23
VIII	APPENDIXES	24
	APPENDIX A	25
	APPENDIX B	26
	APPENDIX C	27
	APPENDIX D	28

TABLES

No.		Page
1	QUALITY OF FEEDLOT RUNOFF--PILOT STUDY	9
2	TREATMENT EFFICIENCY FOR 3.0 INCHES PER WEEK LOADING APPLIED IN THREE EQUAL FRACTIONS AT 0.15 INCH PER HOUR	10
3	TREATMENT EFFICIENCY FOR 2.5 INCHES PER WEEK LOADING APPLIED IN THREE EQUAL FRACTIONS AT VARYING RATES	11
4	TREATMENT EFFICIENCY FOR 2.5 INCHES PER WEEK LOADING APPLIED IN SEVEN EQUAL FRACTIONS AT VARYING RATES	13
5	MONTHLY PRECIPITATION, WASTEWATER APPLICATIONS, AND RUNOFF DATA, ACRE-FEET	14
6	AVERAGE POLLUTION PARAMETER QUALITY DATA ON SIX TO FIFTEEN SAMPLING DATES	16
7	TIME-RELATED QUALITY CHANGES AT THE FARM POND DISCHARGE	18
8	MASS REMOVAL PERCENTAGES FOR THE OVERLAND-FLOW AND FARM POND COMPONENTS OF THE TREATMENT TRAIN	19

ACKNOWLEDGMENTS

Personnel of Meat Producers, Inc., owners and operators of the feedlot, provided on-site management and operation of the distribution systems for the overland-flow area at the field study site. Everett Reeves, owner and operator of a small feedlot near Ada, Oklahoma generously provided a site for the pilot study.

Lowell C. Penrod, Kenneth F. Jackson, Curtis V. Gillaspy, and Robert L. Smith of the Robert S. Kerr Environmental Research Laboratory staff carried the major burden of sample collection and analysis for both phases of the project.

SECTION I

CONCLUSIONS

The results of a six-month pilot-scale study indicated that the overland-flow method of treatment has potential for treatment of feedlot runoff.

Liquid loadings of 2 to 3 inches per week applied at instantaneous loading rates of less than 0.08 inch per hour appeared suitable for field testing with dosing frequencies in the range of daily to three times per week.

The results of a six-month field test supported the conclusion that the overland-flow method of treatment has potential for treatment of feedlot runoff under humid, subtropical climatic conditions.

SECTION II

RECOMMENDATIONS

The results of the pilot-scale evaluation and the abbreviated field test conducted in this study should be utilized to implement several field tests which will verify the practicality of the overland-flow method for treatment of feedlot runoff. These field tests should be conducted at several locations which are representative of climatic conditions encompassing the major areas of beef production in the United States.

SECTION III

INTRODUCTION

GENERAL

This study was initiated to evaluate the practicality of using overland flow for treatment of runoff from beef cattle feedlots in warm, subhumid regions. This runoff needs to be retained and treated before it can be released to surface watercourses without serious pollutional effects.

BACKGROUND

Confinement feeding of beef cattle has increased rapidly in the Plains States, and rainfall runoff from feedlots has been identified as a major cause of fish kills in this area.[1] Runoff from feedlots frequently contains high concentrations of suspended solids, organics which create biochemical oxygen demand, and nutrients which accelerate eutrophication.[2] Retention and treatment of this runoff at cattle feedlots located in this subhumid area of the Plains States are major problems.

Application of wastewater to the land for reuse or treatment can be an efficient and economical management approach when land is readily available, as it is in the vicinity of many feedlot operations. One method of land based wastewater management which has been used successfully is the overland-flow approach for treatment. Overland flow operates successfully under intermittent or continuous use.[3] The system can be managed to achieve efficient removal of suspended solids, biochemical oxygen demand, and nutrients from concentrated wastewaters.[4] Successful use to date has been with wastewaters from other sources, but the

major contaminants were similar to those found in runoff from cattle feedlots. Adaptation of the overland approach to runoff from cattle feedlots would provide the cattle feeding industry with a new tool for combating a serious problem.

SCOPE AND OBJECTIVES

This study of the overland-flow treatment of feedlot runoff is being conducted in three phases. The purpose of the three-phase approach was to address the theoretical approach in stages with decision-making milestones at the completion of each stage or phase. The first phase of the study was a six-month series of pilot-scale experiments to determine the feasibility of adapting the overland-flow approach to treatment of feedlot runoff. The primary objective for this phase of the study was to make a quick and qualitative evaluation of several system designs. Favorable results from this phase would lead to initiation of the second phase of the study. The second phase of the study would be the operation of a large-scale experimental system at a commercial feedlot. The objective of this phase was to field test three or four of the most promising designs evaluated during the pilot-scale study. The field tests were to be followed by a several-year demonstration of the best system design. This report covers the six-month series of pilot-scale studies and the first six months of data collection for one field experiment.

SECTION IV

EXPERIMENTAL METHODS

The pilot-scale studies were conducted during the winter of 1969 and 1970 at a feedlot located near the Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma. The field tests were conducted during the winter of 1970 and 1971 at a 12,000-head capacity feedlot located in north central Texas.

PILOT-SCALE STUDIES

The pilot-scale studies were conducted on a loam soil with a slope of 4.5 percent. An experimental area measuring 18-feet by 30-feet was bordered with lawn edging to exclude extraneous surface runoff. The experimental area was divided into three plots measuring 6-feet by 30-feet, and a small weir was installed at the lower end of each plot for collection of runoff samples. The native vegetation of mixed grasses was not disturbed during the preparation of the experimental area.

Runoff from the feedlot was collected and stored in a sump prior to application to the experimental area. The wastewater was pumped from this sump to the overland flow plots through a fully automated sprinkler application system which could be adjusted over a wide range of operating conditions. The wastewater was applied independently to each of the three experimental plots through a single fixed nozzle which covered a four-foot diameter circle at the upper end of the plot. Samples of the wastewater applied to the plots and samples of the runoff from each of the three plots were collected at 7- to 14-day intervals throughout the study period.

FIELD TESTS

The field tests were conducted on an Austin silty clay with a natural slope of 3 to 5 percent. An experimental area of eight acres was divided into two areas with terraces at a spacing of about 250 feet. Additional earthwork was conducted to exclude extraneous runoff and to permit operation of four separate experimental plots of about two acres each. The rainfall runoff from the 33 acres of cattle pens was collected initially in four lagoons with a combined surface area of about 22 acres. After a variable period of settling in these lagoons, the collected runoff was pumped into a newly constructed reservoir for storage until it was pumped to the overland-flow area. Distribution to the overland-flow area was achieved through a fully automated sprinkler system equipped with rotating impact nozzles. The distribution system was designed to permit operation of the four experimental areas at different loadings and different frequencies of application. Runoff from the overland-flow areas was measured continuously with Stevens A-35 stage recorders installed on H-flumes[5] and then directed into an existing farm pond with a storage capacity of about 4.5 acre-feet below the spillway. Discharge from the farm pond was measured continuously with a Stevens F-1 stage recorder installed on a 150 degree V-notch weir. Precipitation at the project site was measured with a weighing, continuous recording rain gauge. The layout of the treatment train at the field site is shown in Figure 1 and includes the stations at which liquid samples were collected for analysis.

Water samples collected during the pilot-scale study and the field tests were analyzed for pH, conductivity, total suspended solids, chemical oxygen demand, 5-day biochemical oxygen demand, total organic carbon, total phosphorus, ammonia nitrogen, nitrate nitrogen, and nitrite nitrogen according to Environmental Protection Agency Methods.[6] Kjeldahl nitrogen was analyzed by Technicon Auto Analyzer Methodology[7] which has been checked against the Environmental Protection Agency Methods. Samples collected during the field tests were also tested for algal productivity using the Environmental Protection Agency Method.[8]

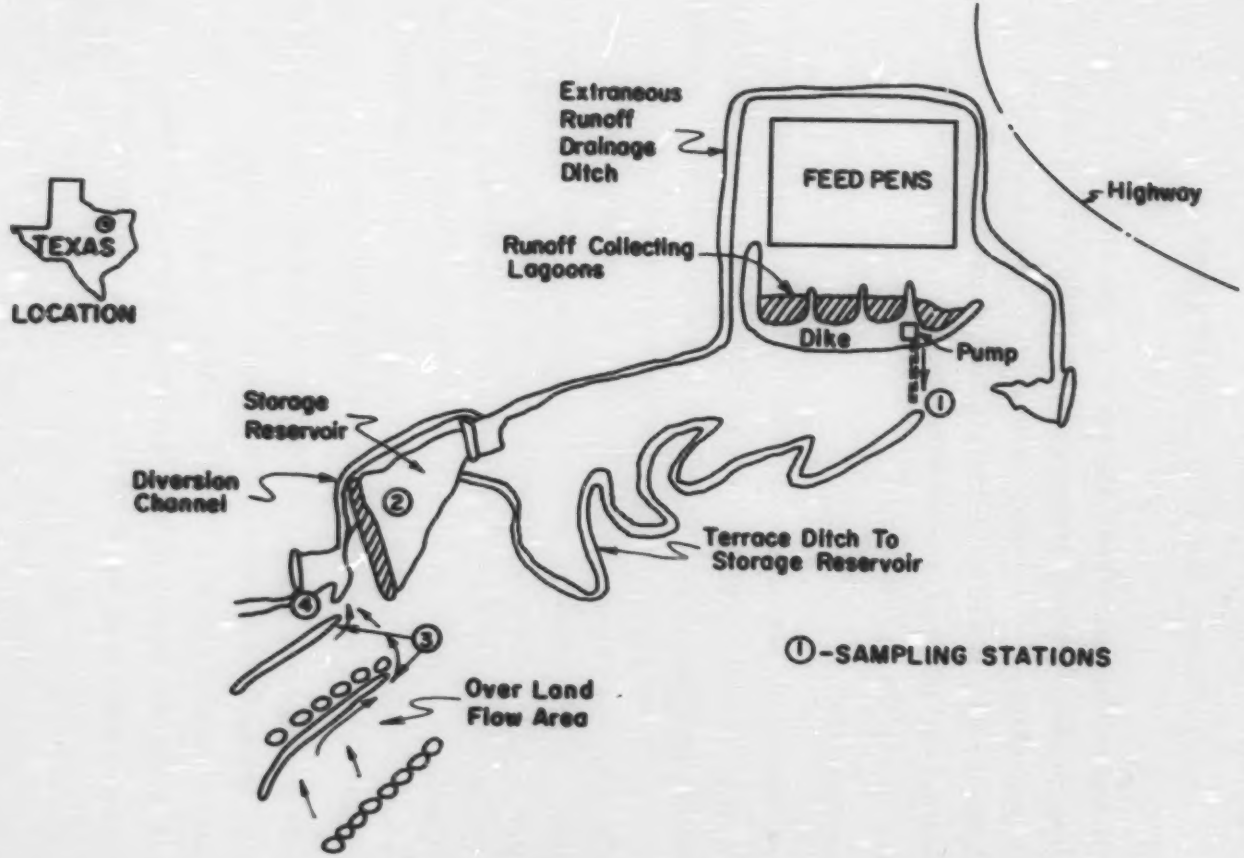

Figure 1. Feedlot and treatment train

SECTION V

OPERATIONAL AND EVALUATION PHASES

The use of short-term, pilot-scale studies was selected as an efficient approach to develop and demonstrate a substantially new application of the spray-runoff approach for land treatment of a wastewater. The pilot-scale studies would provide a quick evaluation of many operational arrangements, and the best of these would be given a much more thorough evaluation during the field test.

PILOT-SCALE STUDIES

The initial two-month period of study was used to evaluate loadings of 1.0, 2.0, and 3.0 inches per week while holding the rate and frequency of application constant. A second two-month period was used to evaluate the effect of different application rates while keeping the loading and frequency of application constant. The final two-month period was used to evaluate further changes in the rate of application and more frequent applications. Nine design and operational combinations were evaluated during the six-month pilot study. The weekly loadings tested ranged from 1.0 inch per week to 3.0 inches per week; application frequencies tested were 3 and 7 times per week; and the rate of application during the spray period ranged from 0.036 to 0.15 inch per hour.

The feedlot runoff being applied to the experimental plots was sampled nine times during the pilot study. The results of the analyses run on these samples are tabulated in Table 1. The minimum and maximum values show that the quality of the feedlot runoff being applied to the experimental plots was quite variable. Maximum concentrations for

Table 1. QUALITY OF FEEDLOT RUNOFF--PILOT STUDY

Parameter	Minimum	Maximum	Mean
pH	7.2	8.3	7.7 (median)
Conductivity, μmhos	2,200	4,500	3,300
	(Concentration, mg/liter)		
Total Suspended Solids	64	1,059	390
Chemical Oxygen Demand	790	2,350	1,400
Total Organic Carbon	250	820	440
Total Phosphorus	18	42	28
Total Nitrogen	43	162	86
Kjeldahl nitrogen	42	160	85
Ammonia nitrogen	10	51	29
Nitrate nitrogen	<0.05	3.4	0.5
Nitrite nitrogen	<0.05	1.8	0.4

several of the parameters were more than three times greater than the minimum values. This variation in the quality of the feedlot runoff can be attributed to differences in the quality of runoff from individual runoff events and to changes which occurred as the collected runoff was standing in the sump between runoff events. The quality data in Table 1 are for a small capacity drain and fill sump and may not be representative of the quality of runoff which would be retained in large capacity holding lagoons.

The initial plot trial was designed to evaluate weekly loadings of 1.0, 2.0, and 3.0 inches per week while holding the rate and frequency of application constant. The rate of application was 0.15 inch per hour, and increments equal to one-third of the weekly load were applied on Mondays, Wednesdays, and Fridays. The results of this trial showed that the 1.0 and 2.0 inches per week loadings did not produce any runoff

from the experimental plots. The treatment achieved for the 3.0 inches per week loading is presented in Table 2. The concentration of most constituents was not reduced or was only slightly reduced by the overland-flow process. The treatment efficiency did not approach desirable levels, and it was evident that this mode of operation had little potential for field testing.

A second plot trial was initiated to evaluate rates of application of 0.05, 0.075, and 0.10 inch per hour while holding the weekly load and frequency of application constant. The weekly load chosen was 2.5 inches per week and the frequency of application was the same three-times-per-week schedule used in the initial trial. The results of the second pilot-scale trial showed that a loading of 2.5 inches per week would produce runoff for each of the selected rates of application under the selected conditions of operation. The treatment achieved for this trial is summarized in Table 3. The treatment efficiencies were somewhat better than for the first trial, and data were obtained for qualitative

Table 2. TREATMENT EFFICIENCY FOR 3.0 INCHES PER WEEK LOADING APPLIED IN THREE EQUAL FRACTIONS AT 0.15 INCH PER HOUR

Parameter, mg/l	Applied feedlot runoff	Plot runoff	
		Concentration	% Reduction
Total Suspended Solids	90	103	0
Chemical Oxygen Demand	1,297	1,025	21
Total Organic Carbon	291	248	15
Total Phosphorus	19.0	18.7	2
Total Nitrogen	50.7	44.9	11
Kjeldahl nitrogen	50	39	22
Ammonia nitrogen	17	9.8	42
Nitrate nitrogen	0.1	5.0	0
Nitrite nitrogen	0.6	0.1	83

Table 3. TREATMENT EFFICIENCY FOR 2.5 INCHES PER WEEK LOADING APPLIED IN THREE EQUAL FRACTIONS AT VARYING RATES

Parameter, mg/l	Applied feedlot runoff	Plot runoff from 0.05 in./hr. loading rate Conc.	% Red.	0.075 in./hr. loading rate Conc.	% Red.	0.10 in./hr. loading rate Conc.	% Red.
Total Suspended Solids	556	444	20	331	40	349	37
Chemical Oxygen Demand	1,586	1,376	13	1,188	25	1,260	21
Total Organic Carbon	554	478	14	388	30	462	17
Total Phosphorus	34	30	12	23.5	31	25.4	25
Total Nitrogen	112.1	75.9	32	63.1	44	82.4	26
Kjeldahl nitrogen	111	75	32	60	46	80	28
Ammonia nitrogen	38	14	63	10	74	12	68
Nitrate nitrogen	0.8	0.7	12	2.8	-	2.0	-
Nitrite nitrogen	0.3	0.2	33	0.3	0	0.4	-

comparison of the three rates of application. Suspended solids and chemical oxygen demand removals were similar for the 0.075 and 0.10 inch per hour rates while removal of these components was substantially less for the 0.05 inch per hour application rate. The 0.075 inch per hour application rate was somewhat better than the other two rates for the remainder of the parameters. Overall, an application rate of 0.075 inch per hour gave the best treatment for a weekly loading of 2.5 inches applied in three equal fractions on Mondays, Wednesdays, and Fridays.

A third and final plot trial was designed to test even lower rates of application by dividing the 2.5 inches per week loading into daily increments. The rates of loading tested in this trial were 0.036, 0.045, and 0.060 inch per hour, and results of the trial are summarized in Table 4. Treatment efficiencies were better than for either of the previous trials and were surprisingly good for such a short duration test on small plots. The intermediate rate of 0.045 inch per hour performed somewhat better for removal of chemical oxygen demand, organic carbon, and phosphorus; otherwise, performance was similar for all three application rates.

FIELD TESTS

The field tests were intended to run for a period of two years and to provide for comparison of four operational approaches involving different weekly loads and rates of application at a frequency of three applications per week. The actual period of field testing lasted only six months from October 1970 through March 1971, when it became necessary to terminate the study. No attempt will be made to separate the results for different loadings and rates of application for this short test period, and the data collected will be combined to show the overall treatment achieved by the overland flow and farm pond segments of the treatment system.

Water Balance Data

During the brief period of the field study, a total of 20.2 acre-feet of feedlot runoff was applied to the overland-flow area. Rainfall added an

Table 4. TREATMENT EFFICIENCY FOR 2.5 INCHES PER WEEK LOADING APPLIED IN SEVEN EQUAL FRACTIONS AT VARYING RATES

Parameter, mg/l	Applied feedlot runoff	Plot runoff from 0.060 in./hr. loading rate Conc.	% Red.	0.045 in./hr. loading rate Conc.	% Red.	0.036 in./hr. loading rate Conc.	% Red.
Total Suspended Solids	460	184	60	188	59	192	58
Chemical Oxygen Demand	786	575	27	537	32	630	20
Total Organic Carbon	300	205	32	160	47	225	25
Total Phosphorus	24.9	19.2	23	14.7	41	17.6	29
Total Nitrogen	62.5	24.9	60	23.4	63	24.6	60
Kjeldahl nitrogen	62.0	24.0	61	23.0	63	24.0	61
Ammonia nitrogen	19.5	1.0	95	1.5	92	2.0	90
Nitrate nitrogen	0.3	0.2	33	0.2	33	0.2	33
Nitrite nitrogen	0.2	0.7	-	0.2	-	0.4	-

additional 4.2 acre-feet of loading to make a total loading of 24.4 acre-feet of liquid to the overland-flow area. Evaporative losses and some deep percolation resulted in about 60 percent of the applied wastewater being lost on the overland-flow area, and only 9.0 acre-feet of liquid was discharged from the overland-flow area to the farm pond. Additional evaporative and seepage losses very likely occurred in the farm pond, but the discharge from the farm pond was 9.6 acre-feet due to an undetermined amount of surface runoff from other sources entering the farm pond. Monthly data for rainfall, wastewater applications, and the two points of runoff measurement are summarized in Table 5. These data will be combined with chemical quality data in a subsequent section to show the treatment efficiency in terms of mass removals.

Chemical Quality Data

Chemical quality data were collected at four points in the treatment train. These points were the collecting lagoon, the newly constructed holding lagoon, the combined runoff from the overland-flow area, and the discharge weir of the farm pond. The major points of interest for this study

Table 5. MONTHLY PRECIPITATION, WASTEWATER APPLICATIONS, AND RUNOFF DATA, ACRE-FEET

Month	Applied to overland-flow area			Runoff overland flow	Discharge from farm pond
	Precipitation	Feedlot runoff	Total		
October	1.5	5.4	6.9	0.6	0.3
November	0.3	5.3	5.6	1.5	1.2
December	0.6	4.0	4.6	3.5	3.3
January	0.7	2.0	2.7	1.6	2.2
February	1.1	3.5	4.6	1.8	2.6
Total	4.2	20.2	24.4	9.0	9.6

were the holding lagoon (the liquid being applied to the overland-flow system), runoff from the overland-flow area, and the discharge weir of the farm pond (final effluent from treatment train). The average chemical quality at the four sampling stations is presented in Table 6. The quality of feedlot runoff in the collecting lagoons did not exhibit any definite trend of quality change during the six-month study period, as is shown by the data in Appendix A. There was a substantial change in quality upon pumping the liquid from the collecting lagoons to the newly constructed holding lagoon. The apparent increase in total dissolved solids upon pumping the liquid from the collecting lagoons to the holding lagoon is an artifact of data collection. The holding lagoon was filled in late September with feedlot runoff which had been stored in the collecting lagoons for up to a year. As is shown by the data in Appendix A and Appendix B, this charge of wastewater had a total dissolved solids content greater than that of the feedlot runoff accumulating in the runoff lagoons during the study. The total dissolved solids of the second charge to the holding lagoon (pumped in early January) was comparable to the total dissolved solids content of the collecting lagoons. The quality changes effected by the overland-flow area are modest, but it should be recognized that these quality changes were accompanied by evaporative losses and soil percolation which reduced the quantity of liquid from the 24.4 acre-feet applied to 9.0 acre-feet which flowed into the farm pond. This 63 percent reduction in the quantity of liquid flowing from the overland-flow area into the farm pond represents a dramatic reduction in mass loading of pollutants on the farm pond in relation to a direct discharge to the pond. The substantial quality changes observed between the overland-flow area and the farm pond discharge (changes in the farm pond) are partly due to dilution by the undetermined amount of runoff entering the farm pond from other sources in addition to metabolic conversions by life in the farm pond. The comparatively low total dissolved solids content of the farm pond discharge is indicative of this dilution effect.

Table 6. AVERAGE POLLUTION PARAMETER QUALITY DATA ON SIX TO FIFTEEN SAMPLING DATES

Pollution parameter, mg/l	Collecting lagoons	Holding lagoon	Overland-flow runoff	Farm pond discharge
Total Dissolved Solids	1,110	1,400	1,480	660
Total Suspended Solids	195	104	63	12
Chemical Oxygen Demand	430	350	310	125
Biochemical Oxygen Demand	63	28	12	5
Total Phosphate	13.5	4.0	2.0	0.5
Total Nitrogen	27.7	15.4	13.4	5.4

The data summary presented in Table 6 does not show time-related changes in quality. Operations at the feedlot and the short duration of the study prevented observation of meaningful time-related quality changes at all sampling points except for the farm pond discharge. Some time-related quality changes for this sampling station are summarized in Table 7. The total dissolved solids increased substantially for about 3 months and then stabilized at about 60 percent of the total dissolved solids content of the runoff coming from the overland runoff area. The suspended solids, total phosphorus, and total nitrogen content of the farm pond discharge showed similar time-related changes, but they did not show a steady increase with increasing time of operation. It would obviously require a much longer test period to observe meaningful changes for these parameters. The chemical oxygen demand also exhibited an irregular pattern of changes, but it did show a definite increase with time, as did the biochemical oxygen demand. Although the biochemical oxygen demand did show a definite increase with time, it appeared to be stabilizing at a value which would be suitable for downstream release under very stringent regulatory controls based on the 5-day biochemical oxygen demand test.

Mass Removal Data

A more representative presentation of the removals achieved by individual components of the treatment train can be presented by combining the water balance data and the chemical quality data to obtain mass removals. This approach makes appropriate adjustments for the influence of evaporative losses, retention in the soil, losses to deep percolation, and dilution from other runoff sources. The data used to produce Tables 5 and 6 have been combined into mass removal percentages in Table 8. This evaluation shows that the overland-flow component of the treatment system accounts for the major removal of constituents on a mass basis, while the chemical changes and probable dilution which occurred in the farm pond contributed substantially to achieving the overall removals in the 80 to 90 percent range.

Table 7. TIME-RELATED QUALITY CHANGES AT THE FARM POND DISCHARGE

Parameter, mg/l	Days of system operation					
	0	35	63	97	107	127
Total Dissolved Solids	342	437	477	848	832	780
Total Suspended Solids	4	9	9	16	7	4
Chemical Oxygen Demand	78	71	92	149	166	134
Biochemical Oxygen Demand	2	2	2	5	5	6
Total Phosphorus	0.4	0.2	0.2	1.0	0.5	0.4
Total Nitrogen	4.4	3.5	3.6	6.7	6.3	5.1

Table 8. MASS REMOVAL PERCENTAGES FOR THE OVERLAND-FLOW AND FARM POND COMPONENTS OF THE TREATMENT TRAIN

Parameter	Overland-flow area	Farm pond	Combined
Total Dissolved Solids	73	9	82
Total Suspended Solids	59	30	89
Chemical Oxygen Demand	71	12	83
Biochemical Oxygen Demand	77	13	90
Total Phosphorus	78	12	90
Total Nitrogen	67	19	86

Algal Productivity Tests

The algal assay procedure has been developed as a method for determining the potential of a water to stimulate algal growth and hasten eutrophication. This test was included in the field study to measure the before and after treatment response because feedlot runoff is known to have a comparatively high potential to stimulate algal growth. The liquid being sprayed on the overland-flow area and the discharge from the farm pond (the end of the treatment train) were the sampling points selected for the algal productivity tests. One test was conducted in December after 10.7 acre-feet of feedlot runoff had been applied to the overland-flow area. The results of the test for this sampling date were 100 growth units for the before treatment sample and 18 growth units for the after treatment sample. The combined effect of the overland-flow area and the small farm pond on the water quality resulted in a decisively lower potential to stimulate algal growth. A second test was run in February after an additional 9.5 acre-feet of feedlot runoff had been passed through the treatment system. The results of the algal productivity test for samples taken on this date were comparable to those for the previous sampling date. The results of this test were 120 growth units for before treatment and 25 growth units

for after treatment. The close agreement of the results for these two sampling data suggests that the capability of the treatment train to curtail the potential of the feedlot runoff to produce algal growth was relatively stable.

SECTION VI

DISCUSSION

The results of the pilot-scale study must be interpreted in proper perspective since the experimental procedures were selected specifically to produce qualitative information quickly. Relatively low efficiencies were anticipated because the length of the slope was about 15 percent of that normally used for overland-flow and the duration of each trial was a small fraction of the time a soil system needs to stabilize at its expected treatment capability. In light of these experimental limitations, the removals achieved in the pilot-scale study were very encouraging for development of a successful system. The comparatively low removals for chemical oxygen demand and total organic carbon were used as indicators that verified the expected resistance of organics in the feedlot runoff to bio-oxidation, and the field test area was designed with 250-foot terrace spacing to provide a long residence time for the overland-flow area. It was anticipated that this spacing would provide sufficient time for microbial oxidation of most of the resistant organics.

Just as the results of the pilot-scale study must be considered in relation to the desire to achieve quick qualitative results, the field test results presented in this report must also be considered in light of the short duration of the test. The short duration of the field test is a distinct disadvantage because the treatment system had not operated long enough to approach a stable condition, and the results observed are only indicative of what the overland-flow approach might achieve during a winter season start-up with a feedlot runoff which had been stored for many months prior to application to the overland-flow system. Behavior of

an overland-flow system during this period is usually indicative of long-term behavior although treatment efficiencies are somewhat lower than those for long-term behavior. Regardless of the fact that other overland-flow systems have shown improved treatment efficiencies after a year or two of operation, establishment of the overland-flow approach as a viable treatment alternative for management of feedlot runoff will require long-term studies at several locations representing differing climatic conditions.

SECTION VII

REFERENCES

1. Loehr, R. C. Pollution Implications of Animal Wastes--A Forward Oriented Review. U.S. Dept. Interior, Fed. Water Pollution Contr. Admn., Ada, Oklahoma. Report No. 13040---07/68. July 1968. 175 p.

2. Miner, J. R., R. I. Lipper, L. R. Fina, and J. W. Funk. Cattle Feedlot Runoff--Its Nature and Variation. J. Water Pollut. Contr. Fed. 38: 1582-1591, October 1966.

3. Luley, H. G. Spray Irrigation of Vegetable and Fruit Processing Wastes. J. Water Pollut. Contr. Fed. 35: 1252-1261, October 1963.

4. Law, J. P., Jr., R. E. Thomas and L. H. Myers. Cannery Wastewater Treatment by High-Rate Spray on Grassland. J. Water Pollut. Contr. Fed. 42: 1621-1631, September 1970.

5. Field Manual for Research in Agricultural Hydrology. U.S. Dept. Agr., Beltsville, Maryland. Handbook No. 224, September 1962. 215 p.

6. Methods for Chemical Analysis of Water and Wastes. Environmental Protection Agency, Cincinnati, Ohio. EPA Report No. 16020---07/71, July 1971. 312 p.

7. Technicon Auto-Analyzer Methodology, Industrial Method 29-69A. Technicon Corporation, Tarrytown, New York. 1970. 3 p.

8. Algal Assay Procedure--Bottle Test, National Eutrophication Research Program. Environmental Protection Agency, Corvallis, Oregon. August 1971. 82 p.

SECTION VIII

APPENDIXES

Appendix		Page
A	WATER QUALITY DATA FOR THE RUNOFF COLLECTING LAGOONS	25
B	WATER QUALITY DATA FOR THE NEWLY CONSTRUCTED HOLDING LAGOON	26
C	WATER QUALITY DATA FOR RUNOFF FROM THE OVERLAND-FLOW AREA	27
D	WATER QUALITY DATA FOR THE FARM POND DISCHARGE	28

Appendix A. WATER QUALITY DATA FOR THE RUNOFF COLLECTING LAGOONS

Date	Parameter concentration, mg/l					
	TDS	TSS	COD	BOD	T-P	T-N
10-1-70	1,316	174	620	165	21.3	39.9
11-4-70	1,122	107	314	15	17.0	14.7
12-2-70	1,059	216	386	23	11.1	18.9
1-5-71	959	267	396	-	11.3	25.4
2-4-71	1,128	174	403	65	13.6	28.1
2-24-71	1,169	136	298	31	12.6	35.6
3-25-71	1,046	292	569	80	7.9	31.1
Mean	1,114	195	426	63	13.5	27.7

Appendix B. WATER QUALITY DATA FOR THE NEWLY CONSTRUCTED HOLDING LAGOON

	Parameter concentration, mg/l					
Date	TDS	TSS	COD	BOD	T-P	T-N
10-1-70	1,720	112	490	26	2.8	26.6
10-15-70	1,743	35	419	-	3.1	15.8
10-22-70	1,769	39	324	-	3.3	16.3
11-4-70	1,719	39	335	15	3.1	13.7
11-19-70	1,698	56	331	-	2.8	13.0
12-2-70	1,688	81	362	6	3.7	15.2
12-17-70	1,682	92	368	-	3.7	21.5
1-5-71	1,024	180	302	-	7.0	15.5
1-21-71	-	102	231	-	5.4	12.8
2-4-71	1,014	127	367	25	4.6	11.5
2-11-71	1,033	146	345	-	4.4	12.9
2-18-71	1,005	130	357	-	4.6	15.0
2-24-71	-	156	346	27	3.6	12.5
3-11-71	1,051	188	348	-	3.4	11.5
3-25-71	1,032	80	365	69	4.0	17.2
Mean	1,398	104	353	28	4.0	15.4

Appendix C. WATER QUALITY DATA FOR RUNOFF FROM THE OVERLAND-FLOW AREA

	Parameter concentration, mg/l					
Date	TDS	TSS	COD	BOD	T-P	T-N
10-7-70	1,543	4	333	-	0.7	15.0
10-15-70	1,488	32	302	-	0.8	12.9
10-22-70	1,667	46	306	-	1.0	13.6
10-28-70	1,678	34	308	-	0.9	13.8
11-4-70	1,698	46	312	12	1.2	13.4
11-12-70	1,438	38	322	-	1.4	14.2
11-18-70	1,640	41	320	-	1.2	14.0
12-2-70	1,653	73	318	10	1.4	12.4
12-11-70	1,664	93	300	-	1.6	14.2
12-17-70	1,614	60	329	-	2.1	14.1
1-21-71	1,277	104	253	-	3.1	13.0
2-4-71	965	124	281	14	2.7	10.2
2-11-71	1,220	-	-	-	4.8	-
2-18-71	1,150	124	291	-	4.4	14.1
Mean	1,478	63	306	12	2.0	13.4

Appendix D. WATER QUALITY DATA FOR THE FARM POND DISCHARGE

Date	Days of operation	Parameter concentration, mg/l					
		TDS	TSS	COD	BOD	T-P	T-N
10-1-70	0	342	10	78	2	0.4	4.4
11-4-70	35	437	19	71	2	0.2	3.5
12-2-70	63	477	11	92	2	0.2	3.6
1-5-71	97	848	24	149	5	1.0	6.7
2-4-71	107	832	8	166	5	0.5	6.3
2-24-71	127	780	6	134	6	0.4	5.1
3-25-71	158	874	6	183	12	1.0	8.0
Mean	-	656	12	125	5	0.5	5.4